



ChemTalk

ENDOTHERMIC AND EXOTHERMIC REACTIONS

Chem Words

endothermic change or reaction: a change in which energy in the form of heat is absorbed from the surrounding environment resulting in an increase in the internal energy of the system.

exothermic change or reaction: a change in which energy in the form of heat is released from a system resulting in a decrease in the internal energy of the system.

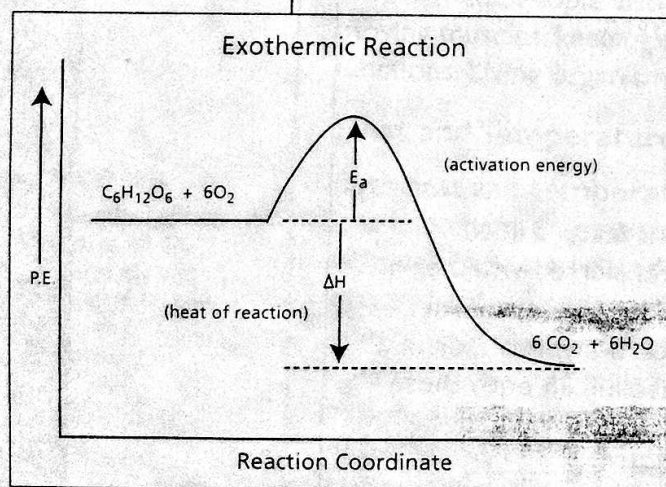
A process is described as **endothermic** when heat energy is absorbed, increasing the internal energy of the system. One example of an endothermic reaction is the cold pack you made with ammonium nitrate. Another example is the decomposition of potassium chlorate. In this reaction, energy must be added to the system in order to cause the decomposition of the potassium chlorate to form the products of oxygen gas and potassium chloride. If you touch a container that holds an endothermic process, it will feel cool to the touch.

An **exothermic** process results when heat energy is released, decreasing the internal energy of the system. If you touch a container that holds an exothermic process, it will feel warm or hot to the touch. One example of an exothermic reaction is the hot pack you made with sodium carbonate. Another example was the combining of sodium hydroxide solution with hydrochloric acid. This reaction produces sodium chloride and water and releases energy to the environment. The terms endothermic and exothermic can be used when describing both physical and chemical changes.

Why is energy so important? In order for a chemical reaction to take place, the particles (reactants) involved in the reaction must interact.

Not all collisions result in a chemical reaction. The particles involved must have enough energy to enable them to react with each other. The colliding particles must have enough kinetic energy to break the existing bonds in order for new bonds to be formed. The minimum energy required for a chemical reaction is activation energy. Bond breaking is an endothermic process and requires an addition of energy and bond formation is an exothermic process and requires a release of energy. (Physics reminder: Kinetic energy is the energy of motion

$$KE = \frac{1}{2}mv^2.)$$



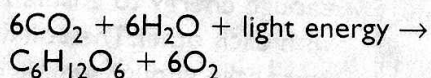
When more energy is released as products form than is absorbed to break the bonds in the reactants, the reaction is said to be exothermic, as shown in the graph. A chemical reaction in which energy is released is called exothermic. The prefix *exo* means exit and *thermo* means heat or energy.

The cells in your body use glucose to get energy for cellular respiration. Glucose plus oxygen (from breathing) provides you with energy.



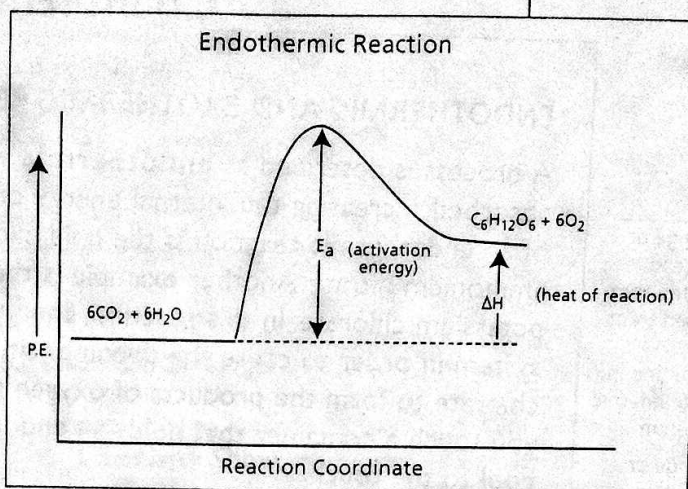
When more energy is needed to break the bonds in the reactants than is given off by forming the bonds in the products, the reaction is said to be endothermic—a chemical reaction in which energy is absorbed, as shown in the second graph. In some endothermic reactions, energy must be added in order for the reaction to occur.

In the process of photosynthesis, plants use energy from light to break the bonds of carbon dioxide and water in order to form the products glucose and oxygen. The glucose produced makes the plant grow and the reaction also provides animals with oxygen:



Conservation of Energy

Energy transfer is an important feature in all chemical changes. Energy is transferred whether the chemical reaction takes place in the human body, like the metabolism of carbohydrates, or in a car, like the combustion of gasoline. In both these cases energy is released into the surroundings.





Checking Up

1. Describe an endothermic reaction.
2. Describe an exothermic reaction.
3. Explain whether each of the following is endothermic or exothermic:
 - a) bond breaking
 - b) bond forming.
4. Distinguish between heat and temperature.

Chem Words

temperature: the measure of the average kinetic energy of all the particles of the material.

The photosynthesis that occurs in living plants and the decomposition of water into hydrogen and oxygen both remove energy from the surroundings. According to the Law of Conservation of Energy, the energy absorbed from the surroundings or released to the surroundings is equal to the change in the energy of the system.

Energy is the great organizing principle of all science. The conservation of energy allows you to better understand the world around you. Energy exists as light energy, heat energy, sound energy, nuclear energy, kinetic energy, chemical energy as well as other forms. The total energy in any closed system remains the same. In the simplest physical systems, it is quite easy to describe the energy changes. When a bowling ball falls, its original gravitational potential energy becomes kinetic energy as the ball increases its speed. After the ball hits the ground, this kinetic energy is converted to sound energy (you hear the crash) and heat energy (you can measure a temperature rise of the ball and ground) and the compression and vibrations of the ground. Each of these can be measured and it is always found that the total energy before an event is equal to the total energy after the event. When a human being is involved, you notice other energy interactions. A person is able to eat food and digest the food. The energy released from this slow-burn of the food (metabolism) is able to keep the body at about 37°C . As all non-living things in the room cool down to room temperature, humans are able to stay warm in the 22°C room environment. People also use the food energy that they ingest for moving muscles, keeping the heart pumping and operating all human functions. Living organisms are superb energy conversion systems.

Heat and Temperature

Both heat and **temperature** have been mentioned in this activity. It is important to note that heat and temperature are not the same, although they are related. Heat is one form of energy. When two materials of different temperatures interact, they exchange heat energy until they arrive at the same temperature. Temperature is a number associated with how hot or cold something is. On a molecular level, temperature is related to the average kinetic energy of the atoms in the material. All particles in a material are in a constant state of motion. The temperature of the material is a measurement of this molecular motion. If the kinetic energy of the particles increases, the temperature increases. Temperature can be

defined as the measure of the average kinetic energy of all the particles of a substance. A thermometer is an instrument that measures temperature. Heat is the transfer of energy, which often results in a change in the kinetic energy of particles—a change in the temperature of the system.

Reflecting on the Activity and the Challenge

Energy is involved in any process that requires the breaking or making of bonds. The process may be a chemical or physical change. Sometimes energy changes are not noticed or measured, but other times an energy change is significant enough to be detected. In this activity you explored both endothermic and exothermic processes. As you select

activities to include in the Cool Chemistry Show, you must be aware of any heat energy released or absorbed. The audience may be interested to learn about the energy changes that accompany chemical processes. In addition, your awareness will ensure that the presentations are safe for both the presenters and the audience.

Chemistry to Go

- Identify the following changes as endothermic or exothermic. (Ask yourself whether the reaction requires the addition of heat energy to occur or does it release energy in the form of heat.)

a) Melting ice.	b) Lighting a match.
c) Dry ice subliming into carbon dioxide gas.	d) Frying an egg.
e) Burning gasoline.	f) Explosion of hydrogen gas.
- The water in a teapot is heated on a stovetop. The temperature of the water increases. Is this an endothermic or exothermic process?
- If a red-hot piece of iron is dropped into a bucket of water, what type of heat change takes place in reference to the water? What type of heat change takes place in reference to the iron?
- Explain in terms of energy flow how a cold pack works on a sprained ankle.
- If ice is at -20°C and you apply some heat by sitting a beaker of the ice on a hot plate, explain why the ice does not appear to be melting.